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Statistical Determinants of Bitcoin

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Statistical Determinants of Bitcoin

A Major Qualifying Project submitted to the faculty of Worcester
Polytechnic Institute to fulfill the requirements of a
Degree in Bachelor of Science
in
Business

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Abstract

Bitcoin, the most prominent and first unregulated Cryptocurrency, has been the focal point of much international spotlight and controversy in the recent years. Due to its unregulated nature, technical requirements, and unknown potential and value, there has been much debate about what to classify Bitcoin as. Along with this, Bitcoin has been extremely inefficient throughout its lifetime, and nobody truly knows how to monitor or predict possible future values. The purpose of this project was to try and get a deeper understanding of the microstructure of Bitcoin, and what microstructures impact its value.

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1.1 Motivation

Bitcoin is a term that has been almost a buzzword in the media today. Over the past three years the public eye has shifted towards the cryptocurrency due to its rapidly shifting, yet trending increasing, value. The cryptocurrency which was once seen as an obscure payment time, often unsupported and lacking significant value back less than half a decade ago, has since risen to a point where people have been able to make a fortune off the asset. Its sudden, unpredicted rise, has led to a bit of chaos in economic circles. Although the cryptocurrency craze has taken over, there is still an uncertain future for Bitcoin and its imitators. Global policies have shifted to address the cryptocurrency bubble, and businesses have felt its ripple effect.

Once more, due to Bitcoin being a rather unmeasured asset up until recently, there is a significant lack of academic papers on the subject in respect to the overall impact of the cryptocurrency. This has led to many academics to race into researching Bitcoin and come to conclusions on the future trends and the overall nature of Bitcoin. Firstly, there is still ongoing debates on what exactly Bitcoin should be considered, a currency or an asset. One paper by David Yermack of New York University published back in 2013 questioned whether Bitcoin can be considered a currency in which he concluded Bitcoin serves as a speculative asset rather than a currency.¹ Another more recent paper published in 2017 by a collective of professors; Dirk G. Baur of UWA Business School, KiHoon Hong of Hongik University, and Adrian D. Lee of the University of Technology, is more modern and published during the Bitcoin bubble. This paper considered the same question on if Bitcoin was a medium of exchange or speculative asset. Despite the environment of Bitcoin changing drastically in the time between the papers, the same conclusion was reached being that Bitcoin is a speculative asset.² Both papers reach this conclusion in the same process, looking at Bitcoin's transaction data, comparing the changing value of Bitcoin to other currencies and assets, and observing the overall volume and nature of the transactions. While these papers used the same process, and came to the same conclusion, there still seems to be arguments in a geopolitical environment on how to treat Bitcoin and other cryptocurrencies. For example, the United States government considers cryptocurrencies to be speculative assets, while the EU considers Bitcoin and others to be a currency.³ Japan on the other hand, considers cryptocurrencies to be a form of prepaid payment similar to credit and gift cards. This shows that there is a lack of consistency and debate that is affecting global economic implications.⁴

The other main topic featured in many Bitcoin essays and research is whether or not Bitcoin is an efficient asset. Andrew Urquhart of Southampton University published such a paper in 2016 that describes Bitcoin's value as inefficient over multiple periods of time when compared to multiple market values of different assets. However, he as concludes that there is a chance that Bitcoin will become efficient in the future. This sentiment is the conclusion reached through empirical studies by multiple academics.⁵

¹ Yermack, David (2013, December). Is Bitcoin a Real Currency? An economic appraisal.

² Baur, Dick; Hong, Kihoon; Lee, Adrian (2017, September 26). Bitcoin: Medium of Exchange or Speculative Assets?

³ Court of Justice of the European Union (2015, October 22). The exchange of traditional currencies for units of the 'bitcoin' virtual currency is exempt from VAT.

⁴ McKenna, F. (2017, December 28). Here's how the U.S. and the world regulate bitcoin and other cryptocurrencies.

⁵ Urquhart, Andrew (2016, September 22). The inefficiency of Bitcoin.

However, once Bitcoin is determined to be highly speculative and inefficient, that is where most studies conclude. There is yet another aspect of Bitcoin that goes rather unnoticed in many research essays being Bitcoin's microstructure. Since Bitcoin is proven to be inefficient in regard to the market, we can conclude that Bitcoin is a unique asset. As such, attention should be turned to all values that are processed in a Bitcoin transaction and during Bitcoin mining. These individual variables known as microstructures, essentially are the ecosystem of Bitcoin. These individual parts are what makes up Bitcoin's nature and all are required to complete a Bitcoin transaction.

The goal of this paper is to find non-linear values in Bitcoin's microstructure and run an analysis to confirm whether or not different Bitcoin microstructures can serve as an indicator on Bitcoin's future volatility and value in USD.

1.2 Bitcoin in Businesses

Adding more to Bitcoin's impact and relevancy is the current impact Bitcoin is having on major businesses around the world. As of writing, there are currently over 80 companies and retailers around the world that accept Bitcoin as a payment type.⁶ However, even though these companies will accept Bitcoin as a payment, doesn't mean they don't have their own internal debates about if Bitcoin is a viable currency. Microsoft is one such example of a company that continues to waiver of the nature and viability of Bitcoin. Since 2014, Microsoft continues change between accepting Bitcoin as a payment and not accepting it frequently. At this time, it is currently accepted on their Microsoft and Xbox storefronts, but this is once again likely to change as more details continue to emerge on Bitcoin's viability as a currency.

Outside of the internal corporate debates on accepting Bitcoin, the cryptocurrency has held an economic effect on some technology companies. NVIDIA is one of the most prominent cases of Bitcoin impacting a company directly. NVIDIA is one of the most popular graphics card companies in the world and has also rose to mainstream market attention after their stock prices surged due to their involvement in auto driving cars and machine learning. The impact Bitcoin has had on the company is on their sales of graphics cards. Once the Bitcoin bubble started, and more people became interesting in mining Bitcoin, the price for graphics cards skyrocketed. This is because Bitcoin mining requires a rather strong computer and processors to mine effectively. With the entire graphics card marketplace seeing inflated prices due to spiking demand, the general public who are not interested in Bitcoin, have been turning away from purchasing graphics cards until the prices return to normal. This hasn't exactly been beneficial to NVIDIA, and as such, the company has begun to focus on developing graphics cards specifically tailored for mining Bitcoin in an attempt to steer the market towards that product, and reduce the demand for all purpose graphics cards.

1.3 Political Implications

As previously referred to, there has been political implications that have been discussed due to the rise in Bitcoin. Most of the recent implications have been purely hypothetical discussions, but the fact that

⁶ Chokun, J. (n.d.). Who Accepts Bitcoins As Payment? List of Companies.

cryptocurrencies are being discussed on the federal level displays the significance of the topic in the current environment. Most discussions have echoed academic research on the topic being that Bitcoin is inefficient and highly speculative. Janet Yellen, a former Federal Reserve chairwoman, states that Bitcoin is a “highly speculative asset” and “not a stable source of value”.⁷ There might be some biases on the government’s Bitcoin interpretation due to it being unregulated. As such, Bitcoin is a direct competitor to the dollar if it becomes a mainstream currency, and the government may not be able to regulate it. It is possible that the government might see the recent spike in Bitcoin’s value as a threat, and might not to publicly take it seriously in an attempt to influence its future.

The only current impact the Federal Reserve can have on Bitcoin is to ensure that banks understand how to monitor Bitcoin transactions. Other than that, the government doesn’t hold any influence over Bitcoin’s value. As such there have been preliminary discussions on whether the government should develop its own cryptocurrency to compete with Bitcoin and other cryptocurrencies, while being able to regulate it. William Dudley of the New York Federal Reserve has confirmed that these discussions have happened, but development and talks are still “very premature”.⁸

2.1 Methodology



Figure 1: Methodology of processing data

To determine the significance of different variables and values to the market price of Bitcoin, first the proper and most accurate data must be acquired from a trading tool, such as Bloomberg. The values for Bitcoin’s microstructures will be obtained from Quandl which is one of the most accurate Bitcoin value databases available for free. For every variable, the process will be the same, being to use the market or microstructure values as the X-Variables, and the Y-Variable always being consistently the Bitcoin market value in USD. From this, the most important outputs are the t-stat and p-value as they will show the significance of each value to Bitcoin’s volatility. For t-stat, a value over 2 shows significance, while a p-value lower than 0.05 shows that we can accept the data and reject the counterargument.

2.2 Regression Analysis of Bitcoin to other assets

The collected data focuses primarily on the relationship between the price of Bitcoin compared to various ETFs. The starting point for all data was 11/1/2013-9/11/2017. This allowed for 1411 instances of Bitcoin’s price, which was reduced to 970 when only utilizing open trading days on the market and linearizing the data.

The maximum percent change for bitcoin over this time frame was 64.8% and the biggest loss was 23.6% with a mean of 0.44% growth per day.

⁷ Buck, J. (2018, April 24). US Fed Chair Speaks Out On Bitcoin and National Crypto.

⁸ Cox, J. (2017, November 29). Federal Reserve starting to think about its own digital currency, Dudley says.

The nature of the processed data is an attempt to figure out if Bitcoin and other cryptocurrencies are a unique asset class, or if the market and other values have any implication on the value of Bitcoin and its value trends.

To prove that Bitcoin is in fact a unique asset class, regression analysis was run. In all instances, the X-variable was the stock market value of the different assets, and the Y-variable is the market price of Bitcoin in USD. Descriptions of the selected stock prices that were selected are as follows:

SPY: To compare to the overall market value.

VIX: To measure against the overall volatility of the US stock market.

VGT: A stable stalwart technology company with high value.

Corn: To measure against commodities.

10-Year Interest: To measure impact of interest rate.

SPY:

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.002115							
R Square	4.47E-06							
Adjusted R Square	-0.00103							
Standard Error	5.283122							
Observations	970							
ANOVA								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	1	0.120858	0.120858	0.00433	0.947548			
Residual	968	27018.22	27.91138					
Total	969	27018.34						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	0.447678	0.16984	2.635887	0.008526	0.114382	0.780975	0.114382	0.780975
X Variable	-0.01428	0.217017	-0.0658	0.947548	-0.44016	0.411597	-0.44016	0.411597

Figure 2: Regression of Spy (X) to Bitcoin in USD (Y)

No significance. Incredibly high p-value displays the likelihood that the null-hypothesis is more likely correct being that there isn't a significance.

VIX:

SUMMARY OUTPUT									
Regression Statistics									
Multiple R	0.017739								
R Square	0.000315								
Adjusted R Square	-0.00072								
Standard Error	5.282303								
Observations	970								
ANOVA									
	df	SS	MS	F	Significance F				
Regression	1	8.501625	8.501625	0.304688	0.581086				
Residual	968	27009.84	27.90272						
Total	969	27018.34							
Coefficients									
	Coefficient	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%	
Intercept	0.443809	0.169711	2.615092	0.009059	0.110766	0.776853	0.110766	0.776853	
X Variable	0.01159	0.020997	0.551985	0.581086	-0.02961	0.052794	-0.02961	0.052794	

Figure 3: Regression of VIX(X) to Bitcoin in USD(Y)

No significance.

VGT:

SUMMARY OUTPUT									
Regression Statistics									
Multiple R	0.007085								
R Square	5.02E-05								
Adjusted R Square	-0.00098								
Standard Error	5.283002								
Observations	970								
ANOVA									
	df	SS	MS	F	Significance F				
Regression	1	1.356292	1.356292	0.048595	0.825573				
Residual	968	27016.98	27.91011						
Total	969	27018.34							
Coefficients									
	Coefficient	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%	
Intercept	0.444526	0.170036	2.614307	0.00908	0.110845	0.778208	0.110845	0.778208	
X Variable	0.039425	0.178844	0.220443	0.825573	-0.31154	0.390391	-0.31154	0.390391	

Figure 4: Regression of VGT(X) to Bitcoin in USD(Y)

No significance. P-Value is incredibly high.

CORN:

SUMMARY OUTPUT					
Regression Statistics					
Multiple F	0.002396				
R Square	5.74E-06				
Adjusted	-0.00103				
Standard	5.283119				
Observati	970				
ANOVA					
	df	SS	MS	F	gnificance F
Regression	1	0.15515	0.15515	0.005559	0.940583
Residual	968	27018.18	27.91135		
Total	969	27018.34			
Coefficients					
	Standard Err	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.447683	0.169796	2.63659	0.008509	0.114472
X Variable	0.010315	0.138356	0.074556	0.940583	-0.2612
					0.281828
					-0.2612
					0.281828

Figure 5: Regression of Corn(X) to Bitcoin in USD(Y)

No significance. P-value is incredibly high.

10-Year Interest Rate:

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.001247							
R Square	1.55E-06							
Adjusted R Square	-0.00103							
Standard Error	5.28313							
Observations	970							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	0.042007	0.042007	0.001505	0.969062			
Residual	968	27018.3	27.91146					
Total	969	27018.34						
	Coefficient	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.447125	0.169631	2.635866	0.008527	0.114238	0.780012	0.114238	0.780012
X Variable	0.003179	0.081955	0.038795	0.969062	-0.15765	0.164009	-0.15765	0.164009

Figure 6: Regression of 10-Year Interest Rate(X) to Bitcoin in USD(Y)

No significance. Incredibly high p-value.

2.3 Significance of Results

The coefficient of the relationship with the SPY index, representing the market, was -0.014, with a t-stat of about -0.066. Both numbers are close to 0, indicating that the relationship between the SPY index and Bitcoin is insignificant. Considering that Bitcoin is a form of currency, this may be to be

expected, as value of currency is rarely directly influenced by market forces. However, considering that Bitcoin is not officially recognized as a currency by the United States government, one would expect market forces to play a role in its value.

A similar lack of correlation was found with respect to the VIX index, representing market sentiment. The coefficient was 0.012, and the t-stat was 0.021. Again, these small numbers represent a very insignificant relationship between the two indices. This result shows that market sentiment has no effect on the value of Bitcoin. Regardless of whether investors feel optimistic or pessimistic about the market, Bitcoin's value continues to soar.

Bitcoin was also compared to the value of corn, used as an example of a fundamental commodity. The coefficient was 0.010, and the t-stat was 0.075. Again, these represent an insignificant relationship. Since Bitcoin does not have any correlation to this commodity, this provides further evidence that Bitcoin is a unique asset class.

The 10-year Interest Rate also had no effect on Bitcoin's value. The correlation coefficient against interest rates was 0.003, with a t-stat of 0.039. These numbers are again very small, showing no relationship between interest rates and Bitcoin's value.

As displayed through the analysis, none of the various asset and market values have any significance on the market value of Bitcoin, hence confirming academic sentiment and its significance as a unique asset independent from the rest of the stock market. The only types of assets that are significant to Bitcoin are the values of other cryptocurrencies that exist, such as Litecoin. However, due to Bitcoin being the first, and most prominent cryptocurrency that is available, those prices are most certainly heavily dependent on the value of Bitcoin, and not the other way around.

3.1 Microstructure of Bitcoin

Now that it is indicated that Bitcoin is a unique asset class that is unaffected by the market in almost every significant way, the best way to observe the patterns and nature of Bitcoin's value is to see how the currency is impacted by certain events that happen within the entire mining process and its overall value. What will be further analyzed is the microstructure of Bitcoin. Microstructures exist within the stock market as well, but the microstructure of the stock market is based heavily around the regulations, charges, and fees of the stock exchange.⁹ Due to Bitcoin being unregulated, a lot of the microstructures of the stock market will not apply. The only limitations are that under the IRS, Bitcoin is considered a property due to tax purposes, whereas in Europe Bitcoin is treated like a currency from a tax point of view and not subject to VAT.

Now that the microstructure of Bitcoin is validated to be significantly different than those of the stock market, certain microstructures of importance must be selected to be analyzed. To have a substantial analysis of the relationship between the market value in USD of Bitcoin compared to a specific microstructure, is that the selected variables cannot be linear or exponential in growth, just as the value of Bitcoin itself. Within this condition, the relevant microstructures that are to be analyzed are as follows; Transaction Volume, Transaction Fees, Miner's Revenue, and Unique Addresses.

⁹ Dimpfl, Thomas (2017, April 10). Bitcoin Market Microstructure.

Transaction Volume: The amount of Bitcoin traded within the 24-hour period of each day. Often serves as the demand indicator for the currency in question.

Transaction Fee: The amount of Bitcoin collected in every transaction that is collected by the miners encouraging them to add it to a block. The fee is typically around 0.0001 per transaction.

Miner's Revenue: $(\text{number of Bitcoin mined per day} + \text{transaction fee}) * \text{market price}$. Essentially a reward incentive for Miners who register their transactions on the blockchain.

Unique Address: An identifier similar to an email that represents the destination of a Bitcoin payment. Typically, a user will create a new address per every transaction.

3.2 Regression Analysis of Microstructures

Due to the ever changing and volatile nature of Bitcoin, the variables will be analyzed in different sample sizes of time. These time periods will be from 2012-2014, 2014-2016, and 2016-April 1st, 2018, the most modern time as of writing. In all scenarios, the microstructure serves as the X variable, and the market prices serves as the Y variable.

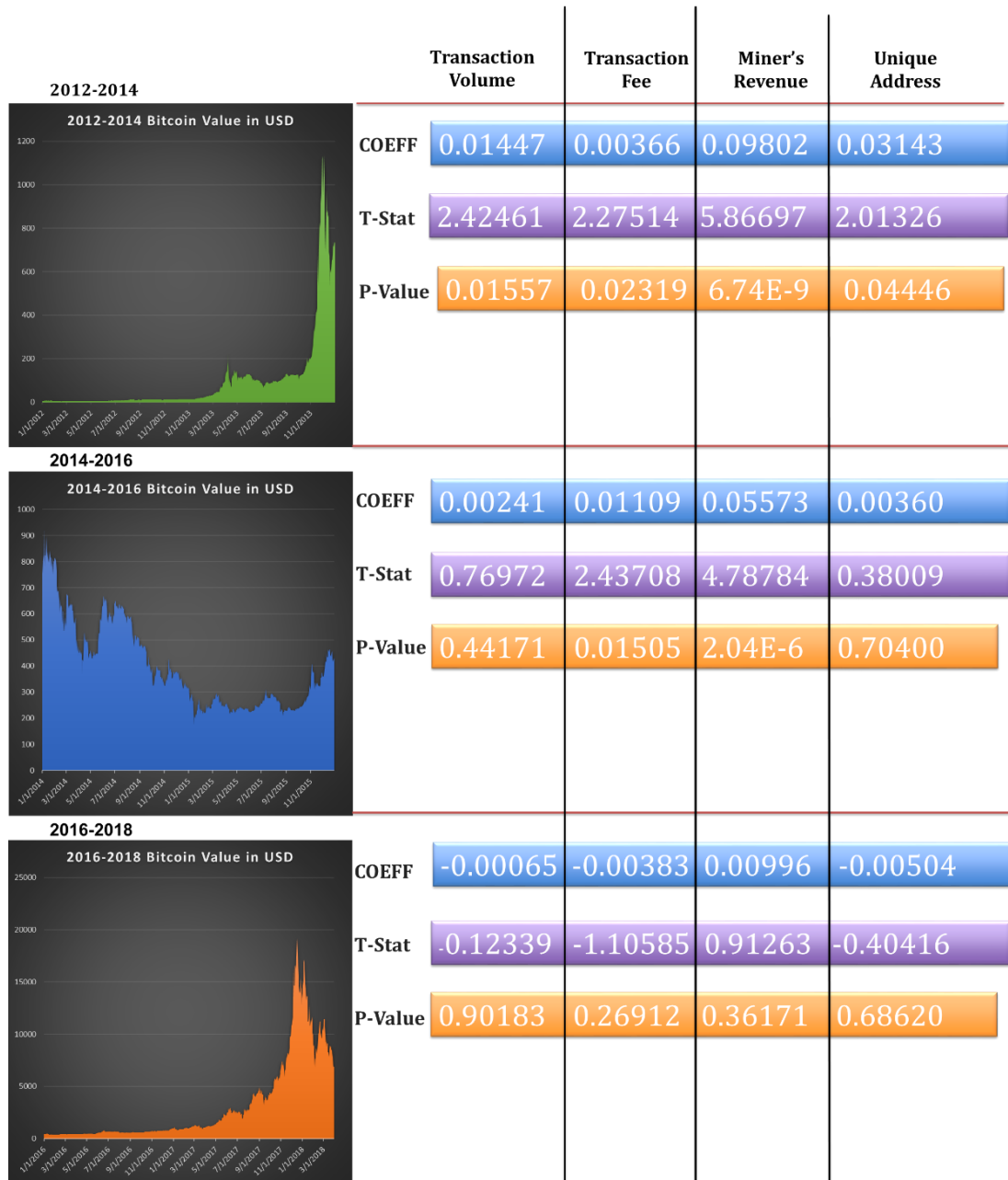


Figure 7: Key statistical indicators of regression analysis performed on the selected four microstructures and the value of Bitcoin during the different time periods

3.3 Significance of Analysis

There is a common trend among the analysis in each of the microstructures. Namely, in every 2012-2014 sample size, all the t-stats are significant. Only transaction fee and miner's revenue are significant in the 2014-2016 sample size. In the 2016-2018 sample time, none of the selected microstructures have a significant t-stat. Likewise, the p-value follows an identical pattern, where only microstructures that are significant in those time samples are we able to reject the null-hypothesis that there isn't a strong relation between the specified microstructure and the value of Bitcoin.

What this goes on to demonstrate is that, as the volatility of Bitcoin drastically altered and the value went through significant swings during the 2017 bubble, Bitcoin's microstructure began to lose significance and correlation to the cryptocurrency's overall value. This goes in line with a lot of political and economic discussions that claims Bitcoin is highly speculative and not efficient. However, it does show the potential for Bitcoin to become less speculative in the future. This is because if one looks at the 2012-2014 time period and even in 2015, back before Bitcoin's volatility and value were all over the map, but still relevant, all the selected microstructures held significant correlation to Bitcoin's market price. This demonstrates, that if the current Bitcoin bubble ends up being an outlier, and the nature of its value returns to what it once was, the microstructure will likely also return to be as significant as they once were. If that were to happen, Bitcoin would no longer be as highly speculative as it is currently interpreted as, due to there being proven variables that hold a significant relationship with the value.

4.1 Global Importance

As stated in the motivation of this study, Bitcoin is having a large global impact in most of the world's major economies. Unlike academics, the world cannot seem to decide how to interpret Bitcoin and how they should react to the unregulated currency becoming more prominent. China made the biggest dent in the Bitcoin bubble in 2017 when they announced that they were immediately making Bitcoin and all cryptocurrency transactions and mining illegal for personal and business use in September of that year. This led to an instant 6% decline in Bitcoin's prices right when the Bitcoin bubble reached its maximum value peak. This was a reaction to fearing the rise of Bitcoin's unregulated nature and concerns of fraud. However, Bobby Lee co-founder of BTCC believes that China will eventually lift the ban due to the resilient nature of the currency, and the belief that it will never go away.¹⁰

Russia has taken the opposite approach to reacting to Bitcoin in the sense that they want to popularize it, but take measures to attempt to regulate it in the country. While cryptocurrencies were previously illegal in the country, it is investing heavily into ICOs in general and wants to capitalize on their rising value as much as possible. The central bank of Russia however disagrees with the government's push for investing into regulated cryptocurrencies due to believing in the same conclusions as academics and other governments, it's too inefficient and speculative. Despite this outcry, Russia still plans on legalizing a regulated form of cryptocurrency mining and transactions by Summer 2018.¹¹

¹⁰ Murphy, D. (2018, January 04). It's only a matter of time before China lifts crypto exchange ban, entrepreneur says.

¹¹ Partz, H. (2018, April 24). Russia's Ministry of Finance Legalizes Cryptocurrency Trading, Central Bank Disagrees.

While academics, governments, and the results of this paper have concluded that Bitcoin is still far too inefficient and speculative at this point in time to become mainstream, it is important to consider what might happen should Bitcoin ever popularize to the point of widespread usage. The implication on the environment due to the large amount of energy required to mine and perform Bitcoin transactions. Quite specifically, one Bitcoin transaction uses just as much electricity as about 549,704 credit card transactions. Bitcoin transactions alone already use more electricity than 159 countries daily. This is all considering that the current state of Bitcoin, albeit prominent, in practice is still a niche. Should Bitcoin, or any other cryptocurrencies in their current state ever become a widely utilized form of payment, even if it's only 5% as prominent as credit card payments, there will be a significant negative effect on global power consumption. Even hypothetically, Bitcoin would never be able to completely replace any currency as our current resources wouldn't be able to support it efficiently. If the United States government were to ever wish to proceed with creating a mainstream cryptocurrency to surpass the current usage of Bitcoin, they should consider the energy situation of the country as well. In order for Bitcoin or cryptocurrencies to come close to becoming a major currency, countries will have to look into more renewable and efficient sources of energy to meet the large demands of cryptocurrency mining and payments.¹²¹³



¹³ Bitcoin Mining Now Consuming More Electricity Than 159 Countries Including Ireland & Most Countries In Africa. (2017, November 23).

4.3 Future Work

Due to the results of this research paper being just as speculative and non-conclusive as Bitcoin itself, it is important to consider future research into the topic. Empirically, keeping track of Bitcoin value and volatility over time remains key. Many academics believe Bitcoin will eventually become efficient, so it might just be a matter of when it does. Likewise, if the Bitcoin bubble and popularity bursts, the impact and significance of Bitcoin's microstructures might become relevant in speculating future value of the currency. Also, should other cryptocurrencies emerge, especially those that are created and regulated by governments, comparing Bitcoin's value and volatility to theirs could prove useful. Will the nature of unregulated cryptocurrencies be identical or similar to those of potential future regulated cryptocurrencies?

Theoretically, keeping track of the environmental significance of Bitcoin mining will be important in creating a bigger picture of the future potential of Bitcoin. Another interesting topic would be to consider the impact and dangers of "pump-and-dump" schemes and the dangers of fraud in the unregulated marketplace of cryptocurrencies.

5.1 Conclusion

Bitcoin, at this point, shows no signs of losing any importance in the rapidly evolving global economy. It only seems to be fitting considering how rapidly technology advanced in the past three decades, that the overall nature of money and value would eventually be challenged as well. Although, unlike communication being able to change easily with the internet, the challenge to standard monetary value evolving is much more concerning to the global population. Perhaps that's why the current situation with Bitcoin is so volatile and uncertain, due to this outward opposition by governments and society.

Regardless of how the Bitcoin bubble occurred and continues to change, the value still hold weight. Unfortunately, it appears that there is no true way to effectively speculate the nature and movement of Bitcoin. Bitcoin's microstructure still holds the largest significance to Bitcoin's value, even if much of it was lost in the past year. The largest take-away though, is that there was a stretch of time where Bitcoin's microstructure could serve as a significant indicator of Bitcoin's volatility and potential changes in value, even when the asset was deemed inefficient by market standards. Since this was the case once, it stands to reason that eventually in the future, even if Bitcoin doesn't become efficient on the market, the microstructures might become strong indicators again. If the current state of Bitcoin due to the 2017 bubble becomes an outlier and not a norm, this will most likely be the case. However, there is currently no way to tell until it happens.

The best course of action will be to continue to monitor the geo-political reaction and policy changes surrounding cryptocurrencies. Changes in government policy so far have been the only clear causes for changes in Bitcoin value, so whatever steps that are taken by major economies around the world will be a major factor in the future of Bitcoin and cryptocurrencies. Until then, Bitcoin will continue challenge policy makers and investors around the world, and eventually there might be a time where Bitcoin will change how the world looks at currency and monetary value entirely.

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